A Review of the U.S. EPA Region 10 Report entitled, "Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington.

Provided by

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Introduction

This document provides review comments on the U.S. EPA Region 10 (EPA) Report of September 2012 entitled, "Relation Between Nitrate in Water Wells and Potential Sources in the Lower Yakima Valley, Washington." This report referenced as "EPA-910-R-12-003" was accessed on October 17, 2012 from the EPA website, (http://www.epa.gov/region10/pdf/sites/yakimagw/nitrate_in_water_wells_study_9-27-2012.pdf).

The report summarizes results of dairy lagoon effluent-irrigated soil, well water, animal manure and process wastewater, and waste water treatment plant influent sampling in the Lower Yakima Valley. This sampling was conducted from February through April of 2010. The report states that the main reason of this study was to investigate the contribution of various nitrogen (N) sources; dairy manure and process generated wastewater (e.g., lagoon effluent), irrigated cropland and residential septic systems, to the high nitrate levels in groundwater and drinking water wells in the study area. Additionally, EPA analyzed samples from these sources for nearly 200 chemical and microbial compounds.

Prior to the targeted sources' sampling and results described in this report, EPA conducted Phase 1 and Phase 2 investigations of the study area. The purpose of the phase 1 study was to identify major sources of nitrate using historical records, and to develop and use a Geographic Information System (GIS) tool to screen and identify sampling sites (sources and sinks of N) during phase 2 and phase 3 (this report) studies. Phase 1 study concluded that livestock with dairy cattle, irrigated cropland, and septic systems and biosolids were the major sources that accounted for an estimated 98% of the N available for land application with potential to its delivery to the aquifer in the study area.

During the phase 2 investigations, EPA conducted sampling of drinking water wells downgradient of the potential N sources that were identified in phase 1. This sampling done between February 22 and March, 2010 was carried out by a two-person team of local residents. The sampling scheme included in situ analyses of water quality parameters including nitrate colorimetric test, as well as laboratory testing and analyses for different N species including nitrate, and chloride and microbial (fecal coliform and *E. Coli*) presence in the well water samples. According to the EPA, phase 2 results "confirmed" that nitrate-N concentrations in several drinking water wells were greater than the EPA drinking water Maximum Contaminant Level (MCL) of 10 mg/L. Phase 2 results were used to identify sampling sites for this report.

Review Comments

Review comments and observation for this report that describes the sampling, analyses, results and findings during the phase 3 of the Lower Yakima Valley study are provided in this section. A summary of the review is provided in the "Conclusions" section. Most comments are related to sampling and results for nitrate from potential sources and sinks in the study area.

Lack of replicated and representative sampling

Statistically, due to the lack of replicated samples of soil, well water, manure, lagoon effluent and septic system influent collected during the study, results do not represent the "population" of potential sources of nitrate and other analytes.

For example, on page 36 (Haak Dairy General Chemistry) it is indicated that five well samples, one from one upgradient water well and one each from four downgradient water wells, were collected and analyzed for different analytes including nitrate. Not taking multiple samples per well presents a major challenge for assessing sample to sample variability within one well and among different wells. Statistically, the normality and independent distribution of just one sample per source cannot be examined for sampling errors, experimental errors, handling, processing and analysis of samples because mean and standard deviation for one sample cannot be calculated. Therefore, the confidence level in comparing results of one upgradient well sample with one downgradient sample per well is low and the differences in results for nitrate and other analytes cannot be compared using standard statistical procedures. Similarly, lack of replicated samples from only one upgradient well of the Dairy Cluster and one sample each from all the downgradient wells (page 55, Table 20) significantly decreases the level of confidence in the results and increases the uncertainty of comparison for nitrate and other analytes from one sample of the upgradient well with one sample each of the 11 downgradient wells.

Another such example is soil sampling in Irrigated Croplands. On page 12 of the study, paragraph 1 describes that there are more than 240,000 acres of cropland in Yakima County. However, only six samples (page 15, Table 1), each one a composite of 30 sub-samples per crop field of an undisclosed number of acres, were collected upgradient from six water wells. It is not known from the study how many total acres of cropland existed upgradient of these wells and why only one composite sample per field was considered a reasonable number of sample to represent the entire field. Therefore, the variability in soil sample results (page 70, Table 28) for different N species including nitrate in Table 28 cannot be explained due to the lack of number of samples per field, per crop, and fertilizer type.

In addition to these examples, results of only one sample from manure pile per dairy and one application field per dairy do not provide statistically sound estimates of actual concentrations of nitrogen and its species including nitrate (page 55, Table 20) or any other analytes.

One consequence of the lack of a representative number and replicated samples is provided as an example from the data provided in this report. On page 44, second paragraph below Table 15, it is stated, "Sample LG01 was taken from liquid waste in a ditch just before entering the lagoon system and contained sulfate. Sulfate was not detected in co-located samples LG-02 and LG-03, likely because of anoxic conditions in the lagoon." On the other hand, as shown in Table C6, sulfate was detected in lagoon sample LG 14. One would expect anoxic conditions in the lagoon where sample LG-14 was collected yet sulfate was detected in this sample but not in samples LG-02 and LG-03.

Lack of strategic sampling of potential sources of nitrate and other analytes

In addition to the lack of replicated sampling and as a result, expected deficiencies described above, the lack of strategic sampling for different N species and other analytes was observed in the report and examples of those deficiencies are provided here.

During early spring of 2010 (February through March) soil samples from one inch depth were collected from an application field or a crop field (Page 15 Table 1). These samples most probably represented the greatest accumulation of N and other analytes during spring when no active utilization of N fertilizer, from organic or inorganic sources, occurs due to absence of crops or due to early growth stage of crops, if growing during early spring. A high accumulation of N at shallow depths (one inch in this case) does not infer that there is movement of nitrate from the soil surface to the groundwater through the vadose zone. A sampling plan should have included to sample soil cores from depths much greater than one inch and to collect water samples from greater depths by installing piezometers (observation wells) in these fields, as well as upgradient and downgradient of these fields.

Additionally, soil samples from one inch depth should also have been taken during the growing season and after the harvest season to assess availability of soil surface N and its species. Soil moisture content at shallow and deeper soil profiles should also have been measured during different seasons of the year to investigate porosity and saturation conditions of soil and to assess how, if any, organic N was converting to nitrate/nitrite due to unsaturated or saturated conditions below the soil surface of these application fields or crop fields.

On page 14, last paragraph, it is stated that no drinking water wells upgradient of the crop fields or septic systems were sampled. Therefore, no upgradient versus down gradient comparisons could be made for analytes measured from the dwongradient wells.

One influent sample per waste water treatment plant (WWTP) was collected "to serve as surrogates" for rural septic systems. On page 76, paragraph 4, it is stated, "Although four wells were selected for this evaluation, all of the residential wells were compared with the WWTP data to determine whether septic systems are a likely source of the nitrate found in any Phase 3 well in the study." However, no assessment (and sampling) of sites with failing septic systems in the study area was conducted or reported. Poorly constructed and failing/failed septic systems (including leach fields) may potentially have contributed to contaminants including nitrate and bacteria to shallow drinking wells in the vicinity.

In a 1993, in a WWTP inspection report (Glenn, 1993) in the Lower Yakima Valley area by the Washington State Department of Ecology it was concluded, "The most frequent problems, each occurring at about half the plants, were:

- potential for chlorine toxicity in the receiving water;
- potential for ammonia toxicity/nutrient enrichment in the receiving water;
- wasteload to WWTP exceeds design criterion(a);
- potential for violation of weekly/monthly average fecal counts; and
- flow measuring instrumentation needs calibration."

It was also observed that "Several plant sites need better maintenance practices; several are understaffed. Two of the WWTPs have considerably more problems than the remaining seven, namely Zillah and Mabton."

According to the phase 3 EPA report, Page 80 last paragraph, age dating (defined as the number of years since the water infiltrated from the surface to the aquifer) method used in this study can determine the age of water up to about 40 years, or approximately 1970. Potential contributions of contaminants in the receiving waters of the study area from WWTPs (DOE, 1993 report above) may have been the potential cause of well water contamination due to infiltration of water from surface to the aquifer.

Inclusion of other possible sources of information would have improved sampling procedures and understanding of various potential sources of groundwater contamination. Some examples of such information are

- History of WWTPs performance in the study area for the past 40 years.
- History of the land use of dairy sites prior to the start of these operations.
- History of well water contamination with nitrate, bacteria and other potential contaminants from reports published prior to establishment of dairies and dairy effluent application on crop fields being studied in this area.

Other observations from the EPA Phase 3 study

Lagoon leakage estimates (gallons per year) provided on page 33, Table 7 and page 50, Table 18 were based upon estimated liquid surface areas, NRCS permeability rates and Ham (2002) seepage rates. Liquid surface area should not have been used in these calculations. These structures do not have vertical walls but resemble an upside down truncated frustum. Lagoon bottom area should have been used for these calculations. Lagoon bottom area will be smaller than the surface area due to 2:1 or 3:1 or similar side slopes of side walls of these lagoons.

From the estimated liquid surface area of lagoons (269,000 sq. ft.) and lagoon system storage capacity (9,400,000 gallons) shown in Table 7, the average depth of the lagoon system in Haak dairy can be calculated. The average depth calculated from this data in Table 7 was 4.67 ft. If the storage capacity included a two-foot freeboard, then actual liquid depth will be less than three (2.67) feet. Lagoons are designed to store manure, sludge, net precipitation, runoff from open lots and free-stall roof area (if designed to accept these runoff volumes) and treat (digest) manure and process generated (flush water etc.) wastewater. The USDA-NRCS Agricultural Waste Management Field Handbook (USDA-NRCS, 2009) states, "The minimum acceptable depth for anaerobic lagoons is 6 feet, but in colder climates at least 10 feet is recommended to assure proper operation and odor control." The EPA Phase 3 report should have clearly defined these manure and process wastewater structures to be for storage only and should have avoided terming them to be "lagoons" if manure treatment and odor control are not the objectives of these earthen storage facilities.

In this EPA study, estimated ranges of Lagoon system leakage rates (Tables 7 &18) are also presented based upon the seepage rate range from a study by Ham and DeSutter published in 2002. However, studies have shown that manure has sealing characteristics that become more effective over the operational life of the earthen structure. Monitoring wells used near a dairy lagoon by Sewell (1978) showed that six months after loading the new lagoon with manure, levels of nitrate in observation wells had declined to near those measured before loading. Sealing of the lagoon with dairy manure was cited for this decrease.

Conclusions

This review document discusses the lack of replicated and statistically deficient sampling of potential sources and sinks of nitrate and other analytes in the Lower Yakima Valley. Other observations pointing out to study assumptions are also provided. This phase 3 report by EPA also points to limited or non-existent information (page 84, Section X) on several important aspects including incomplete information on well parameters and realistic groundwater flow direction specific to the study sites. Lack of historical information and production and management data on dairies and irrigated crop fields also were cited. Additionally, nonexistent or insufficient information on presence of livestock, possible wildlife presence, use of synthetic and organic fertilizers in the vicinity of the residential drinking well water sites further dilute the validity of results shown and conclusions made in this study.

Based upon the data and results provided in this report, no direct correlations can be made between nitrate in water wells and any one specific potential source of nitrogen in the Lower Yakima Valley.

References

Glenn, N. 1993. Yakima River Basin Class II Inspections at Toppenish, Zillaii, Sunnyside, Mabton, Wapato, Moxee, Selah, Ellensburg, and Granger Wastewater Treatment Plants. Washington DOE Report 37-1030. Accessed on 11-19-12 from https://fortress.wa.gov/ecy/publications/publications/93e19.pdf)

Sewell, J.I. 1978. Dairy Lagoon Effects on Groundwater Quality. Transactions of the ASABE 21(5): 948-952.

USDA-NRCS. 2009. Agricultural Waste Management System Component Design, Chapter 10, Agricultural Waste Management Field Handbook, Part 651 Publication number 210–VI–AWMFH, amend. 31, August 2009.